Erosion and the value of topsoil: The long view

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We’re a soybean state

...not much protection for the soil
Missouri: one of the most erosive areas in the U.S.

> 5 tons/acre/yr

WHY? A lot of soybean, a lot of silt + some slope
...but one of the most improved

Erosion down > 3 tons/yr from 1982 to 1992
Orange = More than twice the ‘tolerable’ erosion rate (1982)
1992: Orange area (more than twice the ‘tolerable’ erosion rate) is much smaller, but most ag areas of Missouri are still above the ‘tolerable’ rate.
Water erosion on U.S. cropland

Billion tons/year

How big of a problem is erosion?

Late April 2012, 30 miles north of Columbia

Gullies following the planter rows (channeled by the planter furrow) About 12 inches wide, 30 inches apart

Average erosion loss 1.0 inches of topsoil
Could be replaced by growing grass for 100 years

About 2.5” deep
Erosion just outside Columbia
Late April, 2012
Residue matters
3” rainfalls: 50 to 100% more than 50 years ago
Impacts of erosion

• Collapse of dozens of early historic and prehistoric civilizations: The long view
• Collapse of agriculture in the U.S. Piedmont
• Impact on corn & soybean yields in central Missouri
Argolis, Greece

- 7000 B.C. — Simple agriculture begins
- 4000 B.C. — Agriculture intensifies
- 3000 B.C. — Major civilization
- 2500 B.C. — Civilization collapses
- 1500 B.C. — New civilization
- 200 B.C. — Civilization collapses
- 900 A.D. — New civilization
- 1200 A.D. — Civilization collapses

Importing half of their food from Sicily and Egypt

Soil Erosion
“The rich, soft soil has all run away, leaving the land nothing but skin and bone”

--Plato, 400 B.C.
Rome & Soil Erosion

• Rome founded 750 B.C., Roman Empire started 500 B.C.

• By A.D. 400 (900 years of Empire):
  – 75,000 farms had been abandoned in central Italy
  – It was a crime for the son of a farmer to leave the farm
  – Most food was imported from conquered lands
Rome & Soil Erosion

- Erosion estimates based on current position of ancient structures:
- Roman cistern 36” above current soil line
- Via Prenestina (basalt road) several feet above surrounding soil
Ruins in North Africa
Ruins in North Africa

- 60,000 seat Roman amphitheater suggests large population
- But Roman agriculture ruined the soil
- Today’s population is 5,000 within a day’s walk
Devastating erosion
Closer to home

- Used to be a major ag region
- “Soil erosion was rampant from early times”
- “Most old agricultural fields are now in pine forests”
Red clay subsoil (all that’s left, topsoil is long gone) = CRAP
Massive gullies, North Carolina 1911
Erosion on an Alabama hillside, 1937

Why the south?
‘Long’ history
Low residue
Tobacco (VA, NC)
Cotton (SC, GA, AL)
Hugh Bennett, first Soil Conservation Service director

• Timed his testimony to the Senate to coincide with the arrival of a massive dust storm in Washington, D.C.—April 2, 1935
• Led to the formation of the Soil Conservation Service
Topsoil depth affects water delivery to crops

Plant-Available Water Capacity (inches H₂O / 40 inches of soil):

- Summit: 7
- Side-slope: 6
- Claypan: 5
- Toe-slope: 4
- 55-65% clay: 7
- 25-30% clay: 10

Legend:
- 55-65% clay
- 25-30% clay
How do erosion and topsoil depth affect yield?

• Small-plot experiments 2009-2011 near Columbia—mostly 1 to 18” of topsoil
  – Newell Kitchen and others (Ag Research Service)
• Corn
  – 4.6 bu/acre per inch of topsoil in 2009
  – 1.1 bu/acre per inch of topsoil in 2010
  – 2.9 bu/acre per inch of topsoil in 2011
• **Average 2.9 bu/acre per inch of topsoil**
• Similar to 2.2 bu/acre per inch of topsoil measured in another field in 1999 & 2001
2009 yields:
Severe erosion 105
Slight/no erosion 190
How do erosion and topsoil depth affect yield?

• Soybean
  – 0.1 bu/acre per inch of topsoil in 2009
  – 0.5 bu/acre per inch of topsoil in 2010
  – 1.5 bu/acre per inch of topsoil in 2011

• Average 0.7 bu/acre per inch of topsoil
Soybean Yield

<table>
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<tr>
<th>Level of erosion</th>
<th>2010</th>
<th>2011</th>
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<tbody>
<tr>
<td>Severe</td>
<td>44</td>
<td>22</td>
</tr>
<tr>
<td>Moderate</td>
<td>51</td>
<td>41</td>
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<tr>
<td>Slight</td>
<td>44</td>
<td>46</td>
</tr>
<tr>
<td>Depositional</td>
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Note: Different letters indicate significant differences.
120 Years of Erosion
Field near Centralia, Missouri

Analysis: Brent Myers
120 Years of Erosion

Field near Centralia, Missouri

Average 7.7” of topsoil lost from erosional areas since farming started
Soybean: 7.7” x 0.7 bu/inch = 5.4 bu/acre x $15/bushel = $80/acre/year
Corn: 7.7” x 2.9 bu/inch = 22 bu/acre x $6/bushel = $134/acre/year
Corn-soybean rotation: average $107/acre/year
How big of a problem is erosion?

• It’s a $107/acre problem in the field I just showed you
• Every year
• Add an extra $16/acre (every year) to this field from just one day’s erosion
How can we reduce erosion & save our topsoil?

• Reduce tillage intensity & frequency
  – Leave residue to protect the soil surface
• Grow cover crops to protect the soil surface
tilled

no-till
Erosion and sediment loss:
Average 5 times higher with tillage
Effect of tillage (& compaction) on erosion

- From 2006 demo plots near Columbia

![Image showing comparison of soil in buckets labeled Contentional Tillage, Compacted No-Till, and No-Till. The weights are 3.65 tons/acre, 0.83 tons/acre, and 0.26 tons/acre, respectively.]

5' x 50' Plots
Rainfall Rate 4.4'/hr. applied in 6 - 10 min. intervals over 5 days
2012 demo: artificial rainfall

Chisel-finish plot

Brown runoff (& lots of it)
2012 demo: artificial rainfall

Chisel-finish plot

Brown runoff (& lots of it)
2012 demo: artificial rainfall

No-till plot

Clear runoff (& a lot less of it)
2012 demo: artificial rainfall

No-till plot with killed hairy vetch cover crop

Clear runoff (& much less than no-till plot)
I’m convinced that a cover crop with no-till would have protected this field.
Cover crop: cost vs benefit

- Seeding rye: $20/acre/year
- Killing: You’d burn down anyway
- Equals income loss in corn-soybean rotation from losing 1.4” of topsoil in central Missouri
- Long-term economics:
  - Ahead without cover crop until 1.4” of soil is lost
  - How long will that take?
  - After that, the person who cover-cropped makes more money FOREVER
- EQIP can provide some subsidy: $38/ac, max $25,000 (650 ac)
- Other benefits: water infiltration, weed suppression
Cereal rye, December 13, 2012
Erosion and the value of topsoil: Summary

• Missouri’s soils are naturally erosive
• Soybean residue doesn’t give much protection
• We reduced erosion from 1982 to 1992 (terraces, reduced tillage) but not much since then
• Erosion rates in Missouri are still unsustainable—agriculture here will die if we don’t improve
• We’re contending with more big rains (3+”)
Erosion and the value of topsoil: Summary

• Many civilizations have perished because they couldn’t feed themselves due to topsoil loss
• Takes a long time
• We’ve only been farming here for about 150 years
• Farming on the east coast for much longer, and erosion has ruined many areas for farming (or anything else)
Erosion and the value of topsoil: Summary

• Crop residue provides good protection from erosion
• Cover crops provide even better protection
  – I vote for what’s cheap, and getting it planted on time
• Topsoil is worth $14/acre/inch EVERY YEAR
• It’s not that expensive or hard to protect our topsoil so that we can farm forever
• A rye cover crop can be paid for forever by the value of topsoil that can be lost in a single gully-washer